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10/736928
AD6819USDIV
Appeal Brief, Appendix A, Publication entitled "The Nonwoven Fabrics Handbook"

Rev.3/94

AF/IFW

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

IN THE APPLICATION OF:

MICHAEL ROBERT SAMUELS ET. AL.

CASE NO.: AD6819USDIV

APPLICATION NO.: 10/736928

CONFIRMATION NO.: 5332

GROUP ART UNIT: 1775

EXAMINER: CATHY FONG LAM

FILED: DECEMBER 15, 2003

FOR: SOLID SHEET MATERIAL ESPECIALLY USEFUL FOR CIRCUIT BOARDS

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

APPEAL BRIEF

REAL PARTY IN INTEREST

The real party in interest is the assignee, E. I. DuPont de Nemours & Co., Inc., a corporation of Delaware.

RELATED APPEALS AND INTERFERENCES

None known to Applicants.

STATUS OF CLAIMS

The only claims remaining in the application are claims 16-27, all other claims having been canceled. Claims 16-27 are being appealed.

STATUS OF AMENDMENTS

No amendments have been filed subsequent to the final rejection, so no amendments, other than those previously made and accepted, are pending or were submitted and not entered.

SUMMARY OF THE INVENTION

The application as a whole describes a solid sheet material comprising a nonwoven fabric of high tensile modulus fibers and a thermoplastic with a low moisture absorption, and a metal layer. This sheet is "solid", that is it contains few if any voids, as shown by the fact that its apparent density (sometimes called the "bulk density") is close to the calculated (or theoretical) density if no voids were present.

The appealed claims concern a process for making such a sheet by applying sufficient heat and pressure for a sufficient time period to a multilayer structure containing the thermoplastic polymer and a nonwoven sheet (the combination in various forms) and a metal sheet layer, so that the desired solid sheet is formed. In effect the thermoplastic polymer forms a flowable mass due the application of heat, and the pressure causes the thermoplastic to flow "into" the nonwoven sheet. If the thermoplastic flows enough, i.e., the thermoplastic has a low enough viscosity so that under the pressure conditions and for a sufficient time the voids will be "filled in", and a solid sheet eventually results. At the same time the metal sheet layer is adhered to the (final) layer containing thermoplastic and nonwoven fabric.

As noted in the application such a sheet is particularly useful for circuit boards.

ISSUES

Whether claims 16-27 are anticipated under 35 U.S.C. 102(b), or in the alternative obvious under 35 U.S.C. 103(a), both over Furuta et al. (US 6124004).

GROUPING OF CLAIMS

Claims 16 and 22 are independent claims upon which most other claims depend. Claims 16-21 are a grouping and claims 22-27 are another grouping of claims. These processes differ in what the configurations of the starting thermoplastic and nonwoven fabric are.

ARGUMENT

Before discussing the 102 and 103 rejections in detail, the Furuta reference will be discussed in general. In the final office action of Nov. 19, 2004 Examiner made the following points about what was and was not disclosed in Furuta:

- The fiber material can be a nonwoven fabric (col. 13, lines 4-6).

- The fiber may be an aramid (col. 12, lines 55-64).

- A metal layer may be present in the laminate (col. 14, lines 14-16).

- The metallic foil and fiber reinforced LCP are heat press bonded by heat roll and pressing machine to obtain a laminate (the Examiner cites col. 12, lines 30-37, but this is incorrect, the correct location is col. 14, lines 14-40).

- The laminate is useful as a circuit board (col. 1, lines 15-21, although the term "circuit board" itself is not used).

- "Furuta is silent about the apparent density, but a desired density could easily be obtained by the viscosity of the LCP polymer *(sic)*, and also by temperature and pressure applied to the prepreg."

Applicants agree with the above description of what Furuta does or does not contain, although they believe there are other significant teachings/descriptions in Furuta that are germane to the present claims.

<u>Rejection under 35 U.S.C. 102(b)</u>

It is "axiomatic" that "Rejections under 35 U.S.C. 102 are proper only when claimed subject matter is identically disclosed or described in prior art; in other words, all material elements recited in claim must be found in one unit of prior art to constitute anticipation;" <u>In re Marshall</u> (CCPA 1978) 198 USPQ 344. Here the Examiner has stated that Furuta is silent as to the apparent density of the laminates obtained in that invention. The Examiner has also stated that the desired (presumably in the Applicant's claims) density **could** be obtained by using appropriate temperatures and pressures and to a certain extent Applicants agree with this statement. It is noted however that the amount of time the higher temperatures are present and the pressures are applied is also important.

Also in Furuta it is not inherent from the description that the desired (in the presently rejected claims) density will be obtained. However this is not enough to establish anticipation, "Inherency, however, may not be established by probabilities or possibilities. The mere fact that a certain thing *may* result from a given set of circumstances is not sufficient." <u>In re Oelrich et al.</u> (CCPA 1981) 212 USPQ at 326.

The Examiner also states that "The Examiner is taking the position that the density of the sheet depends on the method that of *(sic)* heating and pressing. Since Applicant has not shown any specific temperature range nor pressure used in his invention, the examiner asserts that Furuta anticipates the presently claimed

processing steps." While temperature and pressure are important variables which in part determine what the properties of the sheet (laminate) produced are, the Applicants are not obliged under the law to state with particularity in the claim what these may be. In this instance the claims merely must state what the general conditions should be, and teach the art skilled in the Specification how to achieve that combination of conditions. To state particular combinations of conditions in this instance would unnecessarily narrow the protection desired, something the Courts have frowned on, see for instance "... however applicant should not be denied use of language necessary to give him the broadest protection commensurate with scope of disclosed invention." In re Grier, (CCPA 1965) 144 USPQ 654. At p. 9, line 25 to p. 11, line 14, a general description of the effects of heat, pressure and time on the consolidation of the multilayer sheet to the final product is described. This not only teaches the artisan how to carry out the invention, but also clearly describes that an almost infinite combinations of conditions may be used (some of which may not be commercially practical, for example very long processing times), and that these conditions depend, for instance, on the types of apparatus and thermoplastic used. Applicants point that they state in the claims that the combination of temperature, pressure and time must be such that a solid sheet is formed. These are conditions, albeit general conditions. Nothing within Furuta indicates that such a set of conditions was proper or desirable, nor actually used.

Another point previously made by the Applicants and not addressed by the Examiner in the final rejection is that Furuta does not mention that the fibers in the nonwoven fabric should be short. As previously argued by the Applicants "While Furuta does state that the fiber is present in the form of a woven or nonwoven fabric (col. 3, lines 4-5), this does NOT mean that the fiber is present in short lengths. Nonwoven fabrics may be made of short fibers or long (essentially continuous) fibers or a combination of the two. Nowhere does Furuta state that his fiber may or should be short fibers." In support of this argument Applicants herewith submit I. Butler, The Nonwoven Fabrics Handbook, Association of the Nonwoven Fabrics Industry, Cary, NC (1999), p. 45-63, which describes various types of nonwoven fabrics manufacture, including those containing long (continuous) and short fibers.

Since the neither desired apparent density and short fiber limitation is mentioned nor inherent in Furuta, the present claims are not anticipated by Furuta.

Rejection under 35 U.S.C. 103(a)

Included in this discussion are the points made about Furuta above concerning the section 102 rejection.

Since Furuta neither discusses nor mentions short fiber or an apparent density close to the calculated density (in other words the part should contain few or no voids), does this reference suggest to the person of average skill that one should (employ this process) to make such solid laminates? Applicants believe it does not, and in some instances teaches away from these "limitations".

Insofar as discussion about the fiber form is concerned, there is little in Furuta, it being at col. 13, lines 4-6, and col. 14,, line 34. In col. 13 it states "The fiber material is preferably used in the form of a fiber, non-woven fabric and the like in view of handling, and more preferably used in the form of a fiber.". As far as Applicants can interpret this, it means the fiber may be a nonwoven fabric and it is preferred that the fiber material be a fiber! Col. 14, line 34 merely states the fiber can be in form of a woven or nonwoven fabric. The Examples are of little additional help. Examples 5, 6 and 7 of Furuta, the only examples (excluding comparative examples) in which fiber is used, use fiber in the form of woven cloth. Therefore Furuta does not even suggest or hint at the use of short fibrous materials.

Furuta does not specifically mention the apparent density of his laminates. The only specific mentions of "properties" or further processing steps actually teach that the fibrous layer purposefully has a large amount of voids. These sections of Furuta are at col. 12, line 65 to col. 13, line 3, and col. 13, lines 19-27. In both of these sections the idea of impregnating the fibrous material with a thermosetting resin is discussed. In order to impregnate the fibrous material with a liquid thermoset resin (before crosslinking), the fibrous material must have voids. Indeed in the passage starting at col. 12, line 65, Furuta discusses the idea of treating the surface of the fibers in order to improve adhesion to the organic fiber material. This makes no sense except in the context that when the thermoset resin is added it comes into direct contact with the fiber, i.e., the LCP is not even contacting at least some of the fibrous material present. The fibrous material (whatever form it is) must contain voids before treatment with the thermosetting resin. In a sense this could be said to teach away from the present claims where such voids are nearly or completely absent in the final product.

The presently rejected claims are process claims to make the above described sheets. In Furuta one would use conditions to presumably emulate the conditions needs to produce the products of Furutua, not the present completely consolidated sheets with few or no voids. Therefore in a sense Furuta could be said to teach away from the present process where such voids are nearly or completely absent in the final product.

Furuta does not provide any directions or other information on specifically how to make "solid" sheets or laminates.

Respectfully, this rejection seems based, at least to some extent, on hindsight. The Examiner has concluded that since Furuta's process **could** be changed to produce the presently desired sheet, it is obvious to do so. However as the Courts have noted, "One of more difficult aspects of resolving questions of nonobviousness is necessity `to guard against slipping into the use of hindsight'; ..... thus court that is deciding issue of obviousness must look at prior art presented from vantage point in time prior to when invention was made, ..." In re Carroll, (CCPA 1979) 202 USPQ 571. In this instance the only motivation for varying the conditions reported in Furuta to produce a sheet with few or no voids, and/or use short fibers, is knowledge of Applicant's invention, and this is not a proper motivation. Since Furuta itself also provides no such motivations or directions for doing so, these claims are not obvious over Furuta.

Applicants authorize the $500.00 fee to be charged to Deposit Account No 04-1928 (E.I. DuPont de Nemours and Company). Applicants authorize to charge any additional fees, if any, to the above account.

Respectfully submitted,

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Dated: 7-15-05

APPENDIX A

16. (Previously Presented) A process for producing a solid sheet, comprising heating ad applying pressure to:
    (a) a multilayer sheet structure comprising at least one sheet layer comprising a non-woven fabric of short high tensile modulus fibers and at least one other sheet layer comprising a thermoplastic polymer having a low moisture absorption; and
    (b) at least one metal sheet layer;

wherein said solid sheet has an apparent density and a calculated density, wherein said thermoplastic polymer fills an effective amount of voids between said high tensile modulus fibers so that said solid sheet has an apparent density that is at least about 75% of the calculated density.

17. (Previously Presented) The process as recited in claim 16 wherein said apparent density is at least about 90% of said calculated density.
18. (Previously Presented) The process as recited in claim 17 wherein said thermoplastic polymer is a liquid crystalline polymer or a perfluoropolymer.
19. (Previously Presented) The process as recited in claim 16 wherein said high tensile modulus fiber is an aramid.
20. (Previously Presented) A circuit board produced by the process of claim 16.
21. (Previously Presented) The process as recited in claim 18 wherein said thermoplastic polymer is a liquid crystalline polymer.
22. (Previously Presented) A process for producing a solid sheet comprising heating and applying pressure to:
    (a) a single layer sheet structure comprising a nonwoven fabric of a short high tensile modulus fiber and a thermoplastic polymer; and
    (b) at least one metal sheet layer;

wherein said solid sheet has an apparent density and a calculated density, wherein said thermoplastic polymer fills an effective amount of voids between said high tensile modulus fibers so that said solid sheet has an apparent density that is at least about 75% of the calculated density.

23. (Previously Presented) The process as recited in claim 22 wherein said apparent density is at least about 90% of said calculated density.

24. (Previously Presented) The process as recited in claim 23 wherein said thermoplastic polymer is a liquid crystalline polymer or a perfluoropolymer.

25. (Previously Presented) The process as recited in claim 24 wherein said thermoplastic polymer is a liquid crystalline polymer.

26. (Previously Presented) The process as recited in claim 22 wherein said high tensile modulus fiber is an aramid.

27. (Previously Presented) A circuit board produced by the process of claim 22.

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THE NONWOVEN FABRICS HANDBOOK

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HOW NONWOVENS ARE MADE AND USED

Nonwovens are made by many different processes. All have three general steps: web forming, web bonding and fabric finishing. Each in turn can be done by a variety of methods. By combining the methods and by choosing from an array of synthetic and natural fibers and their blends, nonwoven fabrics can be designed with properties tailored to many applications. Fabrics can also be made from film extrusion processes. These roll goods are subsequently converted and packaged into products for end-use.

SUMMARY OF PROCESSES

Web Forming

- Dry Laid
  - Carded
  - Air Laid
- Wet Laid
- Spunbonded/Melt Blown

Web Bonding

- Latex Resin Bonded
- Thermal Bonded
- Solvent Bonded
- Needlepunched
- Spunlaced (Hydroentangled)
- Stitchbonded

Fabric Finishing

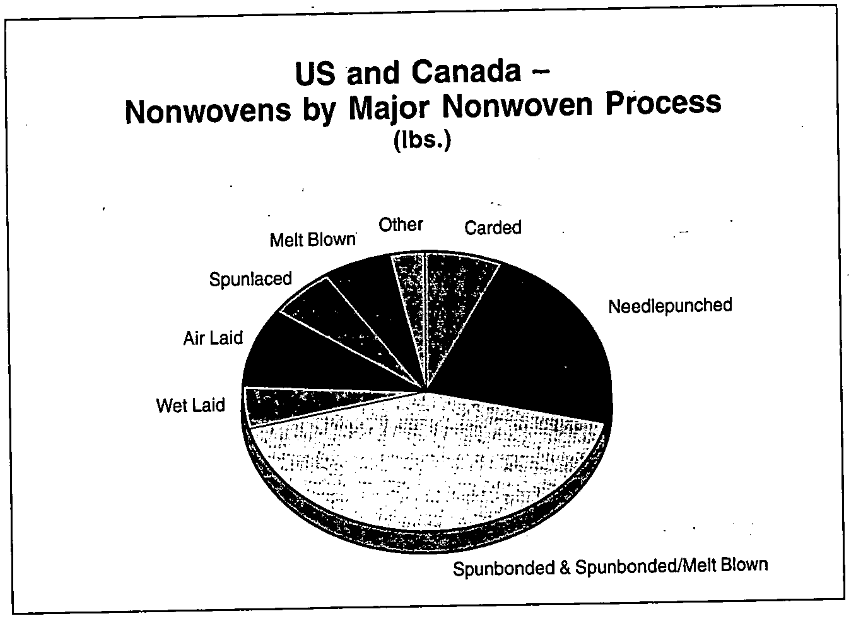
- Softening Processes
- Surface Treatments
- Decorating
- Fabric Stabilization
- Fabric Porosity
- Laminates and Specialty Fabrics

Fabrics from Film Process

- Fibrillated Film
- Apertured Film

Converting

- Roll Goods Converting
  - Die Cutting
  - Slitting
  - Perforating
  - Rewinding
- End Product Converting
  - Die, Knife and Water Jet Cutting
  - Sewing
  - Gluing and Hot Melt
    - Adhesive Sealing
  - Thermal Sealing
  - Ultrasonic Sealing
  - Perforating
  - Impregnating
  - Molding and Heat Setting
- End Product Packaging
- End Product Sterilizing



WEB FORMING

The creation of a loosely held together sheet structure, usually by the laying down of fibers, is called web forming. The fibers can be in the form of short lengths called staple or continuous lengths called filament. The fibrous sheet can even be formed from a plastic film by processes that either split or perforate the film to give a fibrous structure. In most, but not all, processes the web that is formed is too weak to be used. It requires further processing (see Web Bonding).

The web forming step can be done by one of three general methods: dry laid, wet laid and spunbonded/melt blown.

Dry Laid

Dry laid processes include carded and air laid.

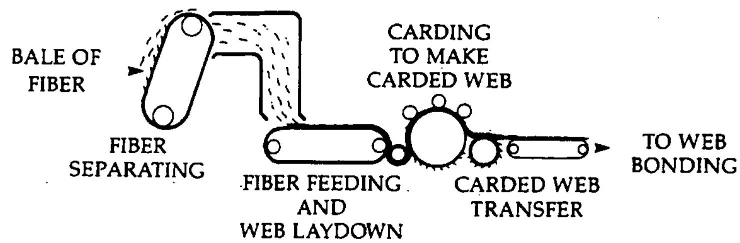
Carded

The carded process uses rotating cylinders covered with fine wires with teeth that comb the fibers into parallel arrays. The web properties are anisotropic. That is, they are stronger in the direction in which the machine makes the fabric than in the direction across the machine. Some cards have randomizing sections which change the direction of fibers as they are laid down in order to produce fabrics with increased cross directional strength. Synthetic and natural fibers up to 150 millimeters long can be used. The weights and thickness' of carded webs

can be increased many-fold by overlapping layers of webs or by pleating a single web.

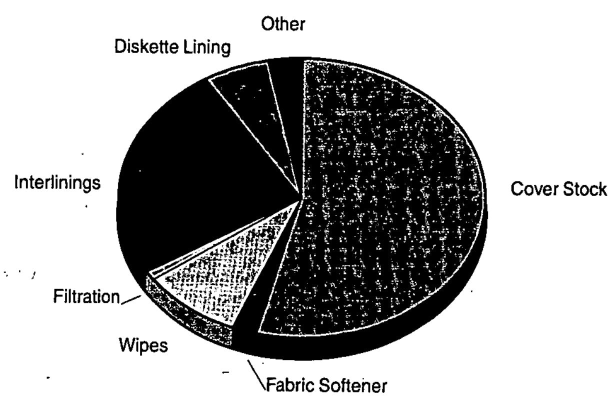
The largest carded nonwoven market in the world is cover stock for absorbent products. Most of this cover stock is carded thermally point bonded polypropylene

WEB FORMING, DRY LAID, CARDED



fabric which competes with spunbonded polypropylene nonwovens in cover stock applications. Apparel interlinings are the next largest carded application, followed by consumer and industrial wipers, fabric softener substrates, and filtration media.

Primary End-uses for Carded Thermal and Resin Bonded Nonwovens
(lbs.)



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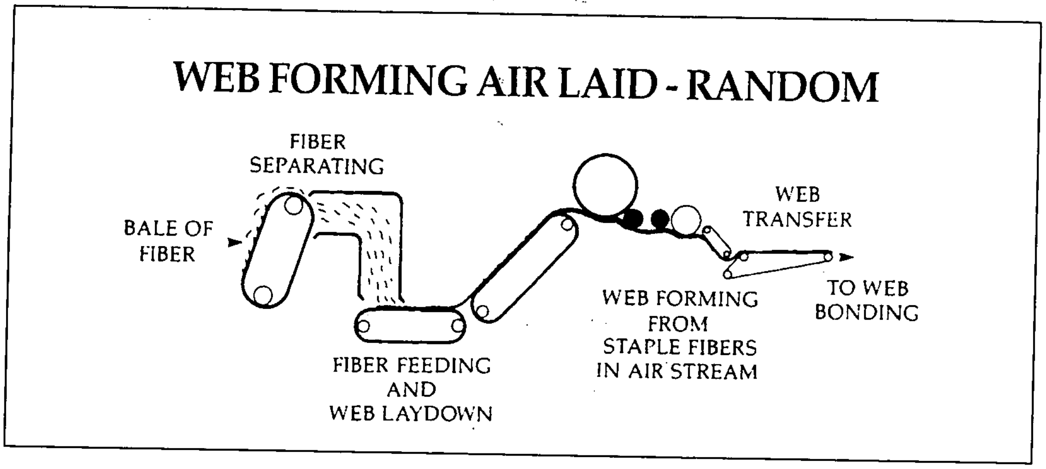
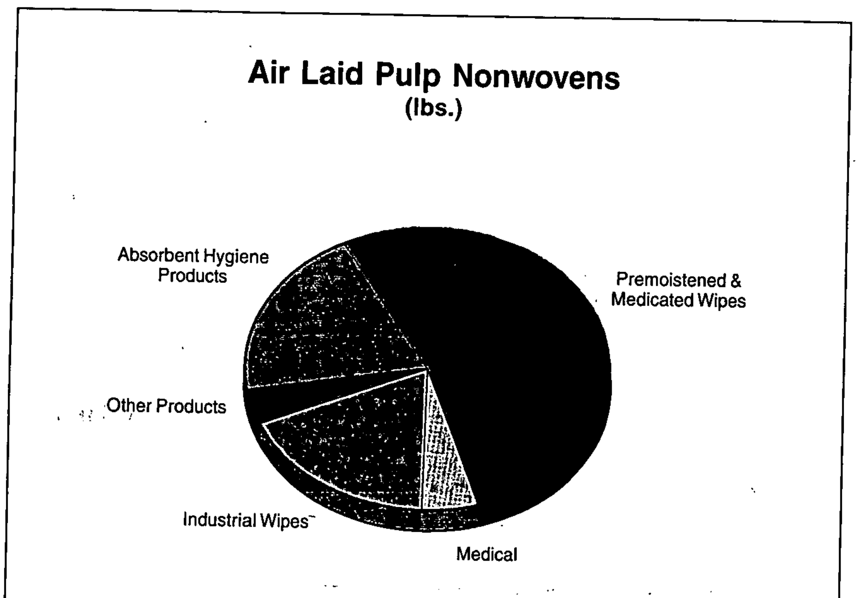
Air Laid

Air laying suspends the fibers in air, then collects them as a batt on a screen that separates the fibers from the air. It is restricted to relatively short fibers and the fiber orientation in the web is generally random. Several manufacturing systems that handle longer fibers are especially useful in preparing thick webs



containing randomly laid fibers. The heavier weights are attained by slowing down the fiber conveyors and increasing fiber feed throughput to the extent that it is commercially feasible. All the air laid systems require machines that separate the fibers and then deposit the fiber onto rotating perforated cylinders



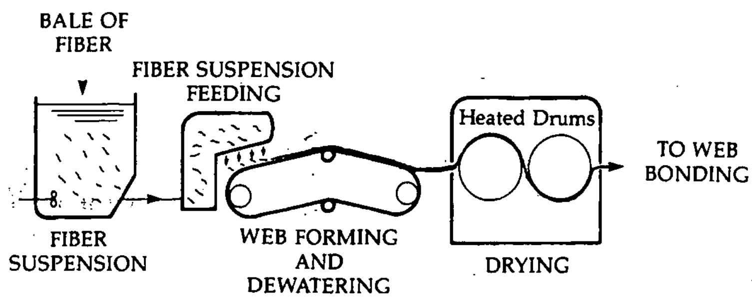
or moving screen belts. Some systems use a card to further separate the fibers before they are deposited in a final web form. The depositing is done with the aid of an air stream.

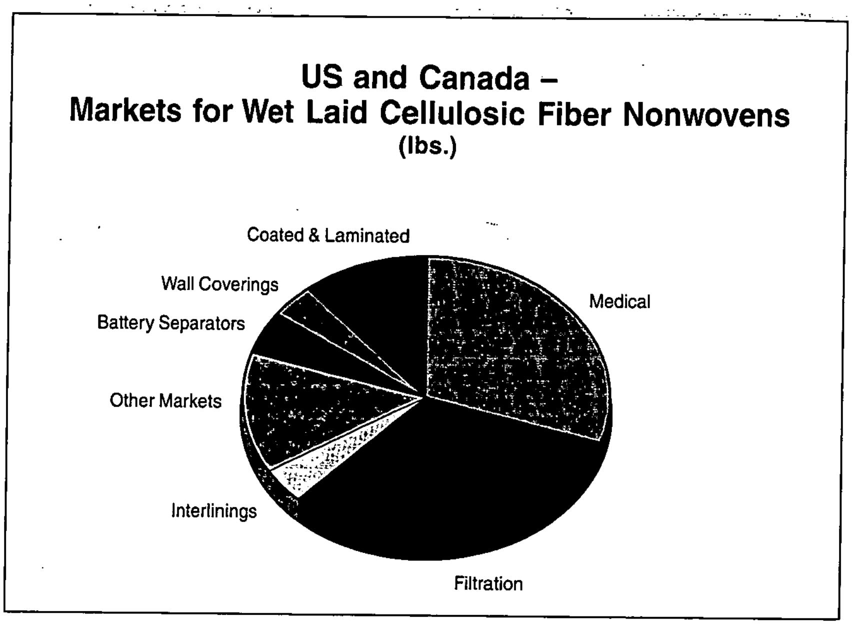
In end-use markets, air laid pulp competes with a fabric made by Scott Paper Company in a proprietary process which involves reverse creping of a wet laid wadding material to which binder has been applied. Virtually all of the volume of air laid and reversed crepe wadding fabrics are used in disposable applications, particularly wiping products. Industrial/institutional dry wipers and premoistened consumer wipes are the largest end-uses. These fabrics are also used as the absorbent cores for certain sanitary napkins and underpad products. They are also used for a range of medical and other industrial applications which require highly absorbent materials.

Wet Laid

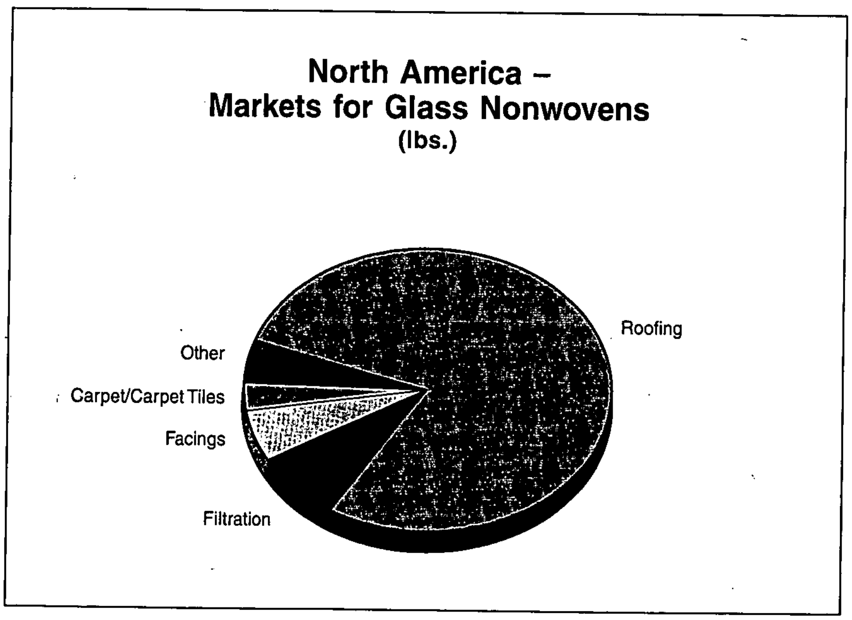
In a wet laid process, fibers are suspended uniformly in water, at very high dilutions of .001 to .005% weight of fiber, and collected to form a sheet by separating the fibers from the water onto a screen - as in papermaking. The screen can be in the form of a wire belt in an inclined position, or a cylinder, where the fiber suspension is fed onto the screen; or two wire belts where it is fed between the two belts. The wet web is squeezed between rolls to remove most of the water and dried further by passing it through ovens. The fibers are laid down in a random orientation to one another. The final fabric has relatively isotropic properties. That is, properties such as strength are similar in all directions in the plane of the fabric. The wet laid process permits adding chemicals, binders and colorants before or after the web is formed. It also permits uniform blending of different fibers. However, it generally is restricted to very short fibers, in the range of 2-6 millimeters, in most commercial processes.

WEB FORMING - WET LAID





In the United States, medical disposables are the largest end-use of pulp/polyester wet laid nonwovens. Tea bags, coffee filters and meat casings are major wet laid applications in the food market. Wet laid nonwovens are also used in a wide variety of industrial applications, such as wallcovering backing, alkaline manganese battery separators, lint-free wipes, vacuum cleaner bags, interlining fabrics, cigarette plug wrap, filter media, cover stock and fire retardant protective apparel.



Wet laid glass nonwovens are primarily used in roofing. Other wet laid glass applications are filtration, facings, carpet backings and carpet tiles, electrical insulation, surfacing veils and reinforcing mats.

Spunbonded and Melt Blown

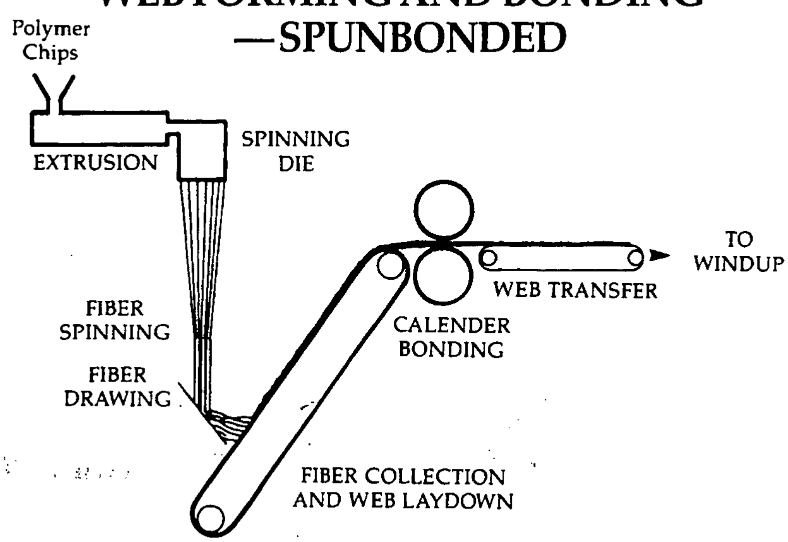
These extrusion processes make webs directly from filaments as they are being spun from molten polymer resin.

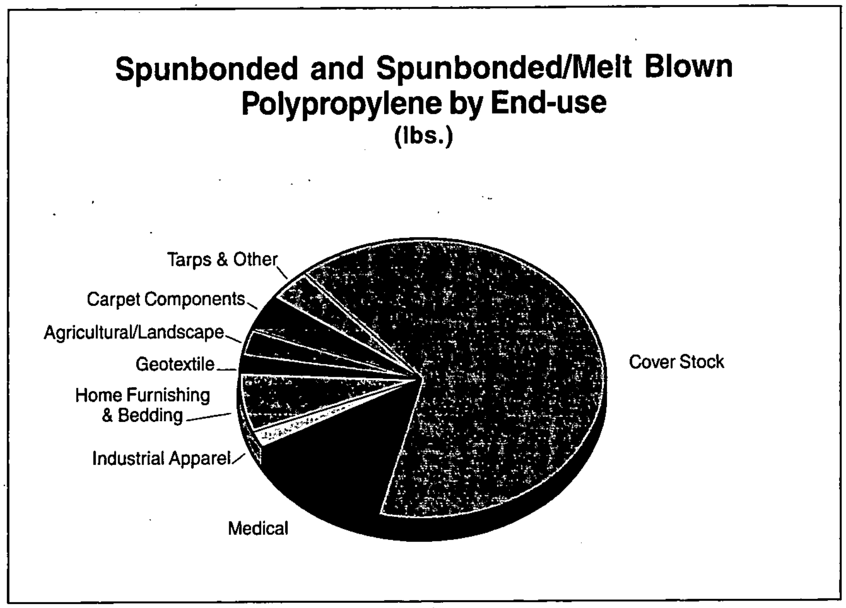
Spunbonded

Spunbonded nonwovens are made in a process in which a thermoplastic fiber forming polymer is extruded through a linear or circular spinnerette. The extruded polymer streams are rapidly cooled and attenuated by air and/or mechanical drafting rollers to form desired diameter filaments. The filaments are then laid down onto a conveyor belt to form a web. The web is then bonded to form a spunbonded web. Spunbonding is an integrated one step process which begins with a polymer resin and ends with a finished fabric.

A version of the spunbonded technology is flashspinning. In this process, high density polyethylene is dissolved, extruded and the solvent is rapidly evaporated causing individual filaments to assume a highly fibrillar form before they are

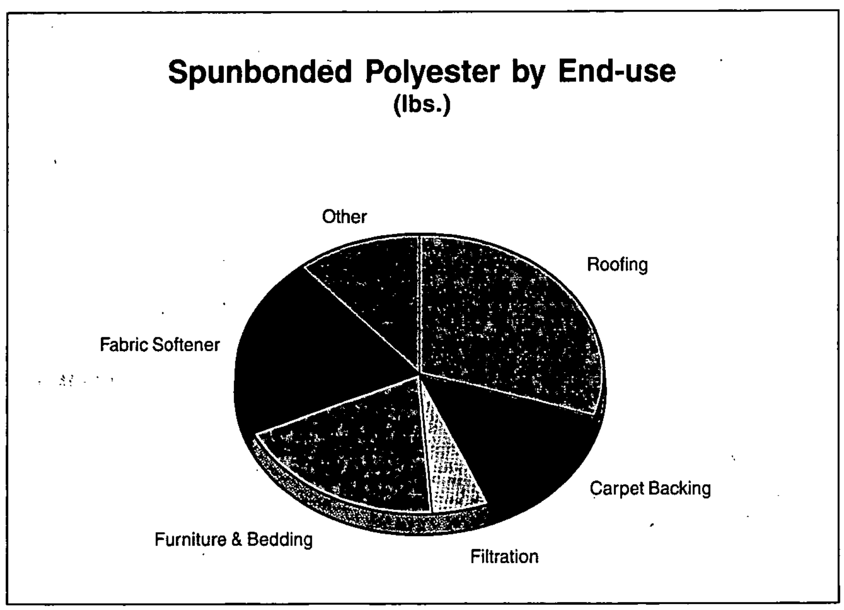
WEB FORMING AND BONDING —SPUNBONDED





deposited on a screen. The web is thermal bonded with a hot calendar roll to form a strong fabric.

About two-thirds of North American spunbonded fabrics produced are made with polypropylene. Cover stock is the largest end-use for spunbonded polypropylene and represents about two thirds of that type of spunbonded material. Other important applications for spunbonded polypropylene are



medical disposables, furniture and bedding fabrics, carpet backing, geotextiles, agricultural fabrics and industrial apparel.

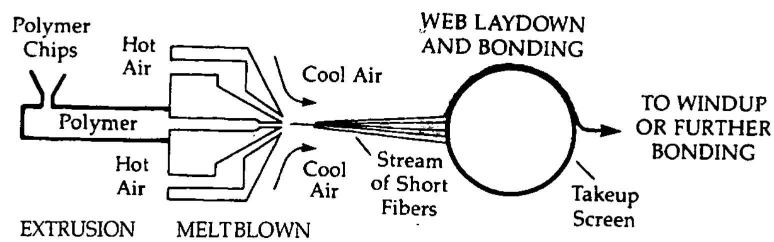
Roofing accounts for a third of the usage of spunbonded polyester in North America. The second largest market is fabric softener substrates followed by furniture and bedding fabrics and carpet backing. Other significant end-uses are filtration media, apparel interlining, and agricultural fabrics.

Melt Blown

The melt blown process extrudes a thermoplastic, fiber forming polymer through a linear die containing 20-40 small orifices per inch of die width. Convergent streams of hot air rapidly attenuate the extruded polymer streams to form extremely fine diameter fibers. The attenuated fibers subsequently get blown by high velocity air onto a collector screen - thus forming a melt blown web.

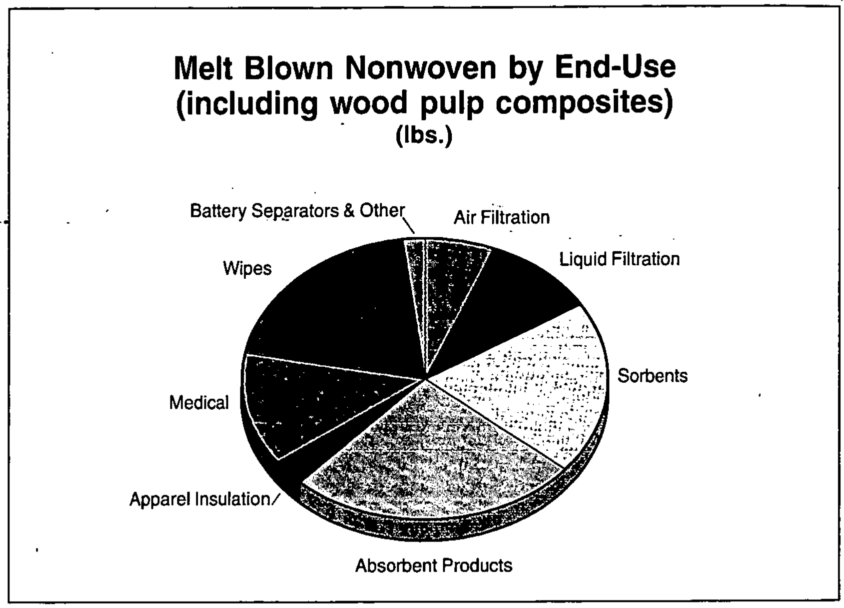
The fibers in the melt blown web are laid together by a combination of entanglement and cohesive sticking. Because the fibers are drawn to their final

WEB FORMING AND BONDING — MELT BLOWN



diameters while still in the semi-molten state, there is no downstream method of drawing the fibers before they are deposited onto the collector, and hence the webs exhibit low to moderate strength.

About 40% of melt blown material is used in the uncombined (monolithic) state. The remainder of melt blown materials are composites or laminates of melt blown webs with another material or nonwoven. Spunbonded materials for example are used extensively with melt blown webs to produce strong spunbonded/melt blown composite material with barrier properties. A variation of the melt blowing process combines the molten polymer stream with a stream of absorbent materials such as wood pulp fibers and superabsorbent powder to



give a strong, soft, yet absorbent web that retains the absorbent fibers and particles tenaciously.

The largest end-uses for monolithic (uncombined) melt blown materials are oil-sorbents, air and liquid filtration media. Melt blown with pulp has captured a significant share of the premoistened baby wipes business in North America. During the mid-1990's cover stock developed as a major end market for spunbonded/melt blown composites.

WEB BONDING TECHNIQUES

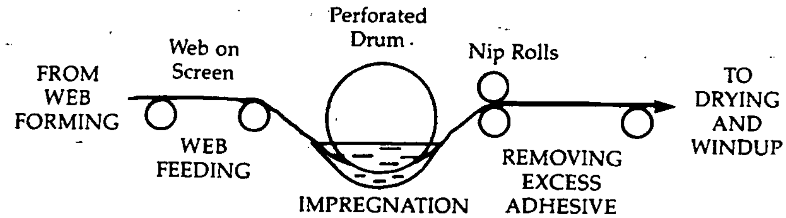
Most webs have insufficient strength in the unbonded form. The individual fibers or filaments must, therefore, be tied together in some way, by gluing, thermally bonding or mechanically entangling.

Latex Resin Bonded

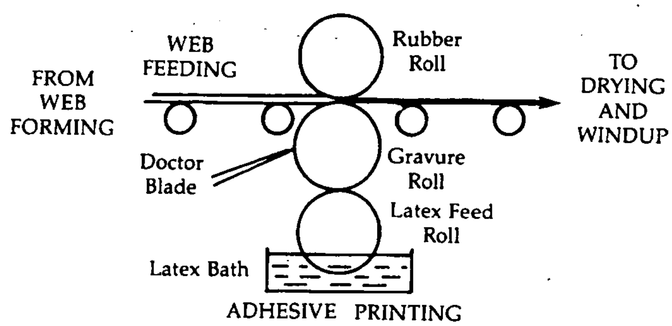
Latex bonding is a common technique. A web, supported on a moving belt or screen, has an adhesive resin called a binder applied to it by dipping the web into the binder and removing the excess, or by spraying, foaming or printing the latex onto the web. These methods of application are simple and can also be used to color the webs by adding pigments to the binder solutions. However,

METHODS OF LATEX BONDING

Saturation Bonding



Gravure Printing

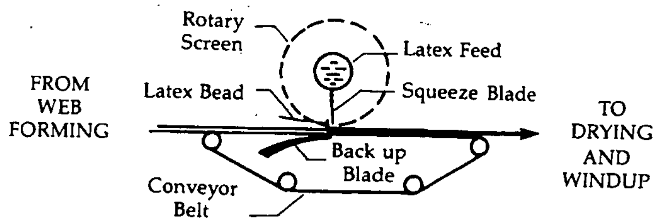


the process requires large amounts of heat to remove water and thereby dry and set the binder into the fabric. More heat is required for dipping or printing compared to that needed for spraying or foaming.

The largest end-uses for resin bonded staple nonwovens are cover stock, wipers, fabric softener substrate and interlinings. This class of nonwovens has lost share in these markets over the last decade as thermal bonded, spunbonded and spunlaced nonwovens replaced resin bonded versions in numerous applications.

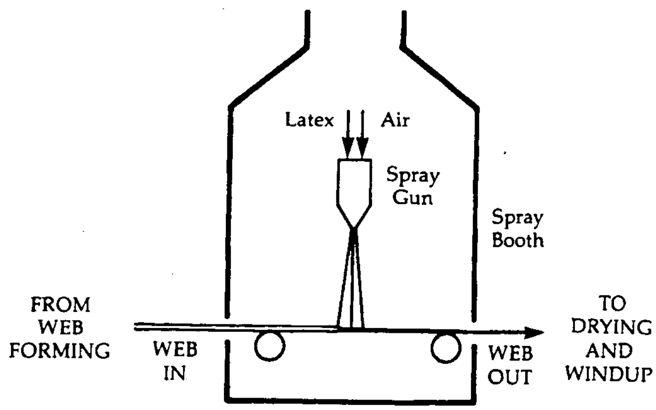
METHODS OF LATEX BONDING

Screen Printing



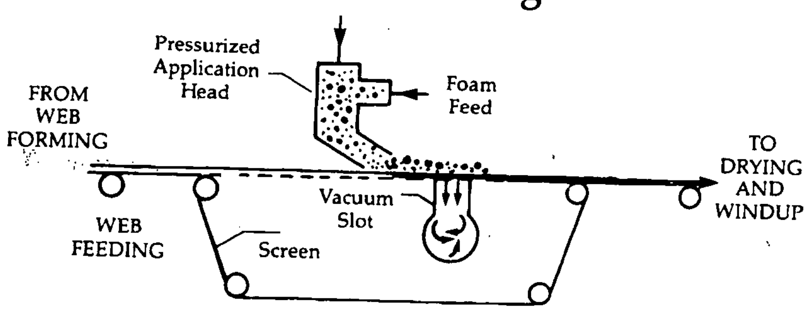
LATEX PRINTING

Spray Bonding



LATEX APPLICATION

Foam Bonding



FOAM APPLICATION

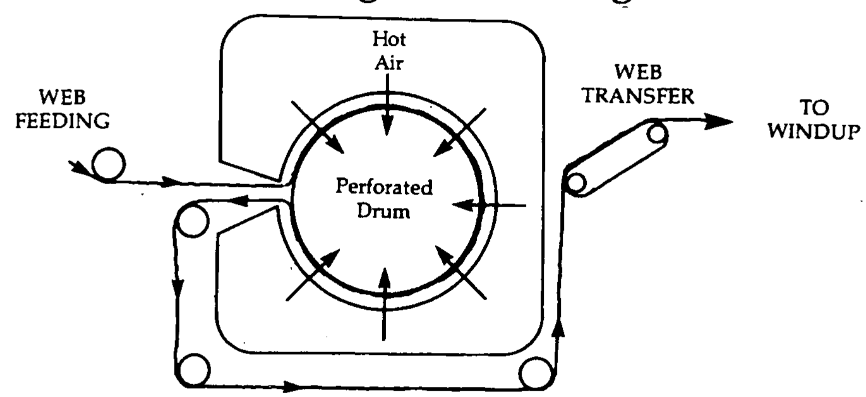
Thermal Bonded

The use of thermal bonding techniques has grown significantly. In these methods, fiber surfaces are fused to each other either by softening the fiber surface, if it melts at low temperatures, or by melting fusible additives in the form of powders or fibers. Bonding powders and fibers can be blended in with the web fibers before the web is formed or they can be sprayed on and into the web with a spray gun. The spray gun for nonwovens is predominantly the non-electrostatic type. Electrostatic guns can be used for webs that are capable of being charged.

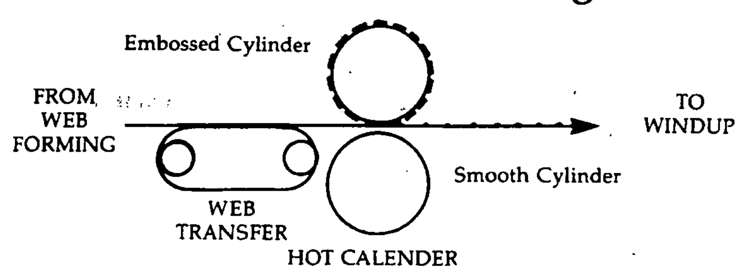
Two common thermal bonding methods are through-air heating and calendering. The through-air method uses hot air to fuse fibers within the web and on the surface of the web to make high loft, low density fabrics. Hot air is either blown

TWO METHODS OF THERMAL BONDING

Through-Air Bonding



Calender Bonding



through the web in a conveyorized oven or sucked through the web as it passes over a porous drum within which a vacuum is developed.

In calender point bonding the web is drawn between heated cylinders that have an embossed pattern so that only part of the web is exposed to extreme heat and pressure. This type of calendering produces strong, low loft fabrics. Ultrasound in the form of ultrahigh frequency energy, applied to small areas, can also be used to cause localized fusion and bonding of fibers, thereby creating a pattern for web stabilization, laminating or quilting.

Thermal bonding fibers and powders are made from fusible polymers such as polyethylene, polypropylene and polyester. When calender bonding is employed, the binder fibers used are often monocomponent; i.e., they are made of one polymer. The fusing process destroys their shape at the bond point, but retains it in the unbonded regions, as the polymer softens and flows to form the bond between fibers. In bicomponents fibers (made with two polymers), one polymer, the low melting component, either covers all of the surface of the higher melting component (sheath/core structure), or is extruded alongside the higher melting component (side by side structure). During fusion and subsequent bonding, the low melting component softens and flows to form the bond while the high melting component maintains its fiber shape and thereby its structural integrity.

Approximately half of North American consumption of thermal bonded carded fabrics is in cover stock. Thermal bonded carded fabrics have also gained share at the expense of resin bonded nonwovens in the interlining market.

Solvent Bonding

Solvent bonding can be used, for a few solvent susceptible fibers, to partly dissolve their surfaces and thereby create an adhesive of themselves. Removing the solvent causes resolidification of the fiber surface and bonding at the fiber crossover points.

Mechanical Bonding

Mechanical bonding, the oldest technique for consolidating a web, is used to enmesh or entangle fibers to give strength to what are usually dry-laid webs. The most common methods are needlepunching and hydroentangling (also called spunlacing). Mechanical bonding methods typically are slower than binder and thermal bonding. However, they yield advantages in strength and aesthetics. Needlepunching is preferred for heavy fabrics, such as those used in geotextiles and for heat and sound insulation, while spunlacing produces soft, lighter weight fabrics used in disposable hospital goods, wipes and home furnishings.

Ultrasonic Bonding

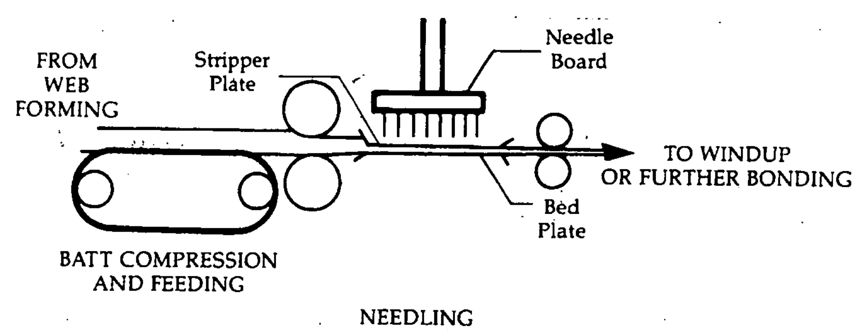
Ultrasonic Bonding is similar to thermal bonding. This process can bond a single nonwoven web or laminate several webs together, including film. In this process, the nonwoven material or materials are drawn between a 'horn', which produces high frequency sound waves, and a rotary calendar, referred to as the 'anvil'. The sound energy generates localized heat through mechanical vibration at the anvil's embossing points to fuse the material. The process is cool, energy efficient and often used to bond or laminate fabrics which would be affected by the other more heat intensive thermal bonding processes. The technology continues to evolve and ultrasonic bonding speeds are rivalling thermal calendar bonding capabilities.

Needlepunched

In needlepunching, barbed needles are punched through the web, hooking tufts of fibers through it and bonding it in the needlepunched areas. The needles enter and leave the web while it is trapped between two plates called a bed plate and stripper plate. The web is pulled through the needle loom by draw rolls. Sometimes needle looms with less closely spaced needles, called tackers, are used to give the web dimensional stability before it enters the main needle loom.

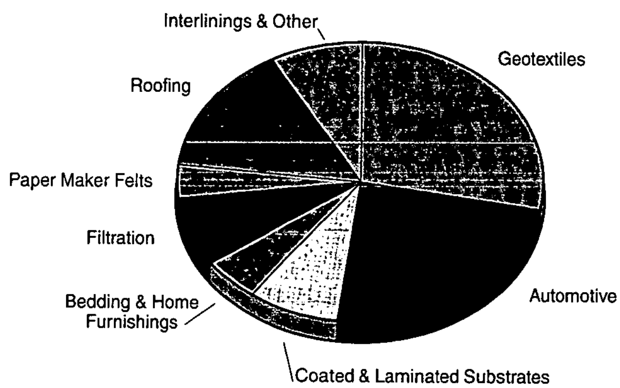
The production of needlepunched fabrics starts with carded, air laid or spunbonded webs that are characteristically bulky. Looms are made to needle webs from the top, the bottom, and from the top and bottom. The largest needle looms are for making papermakers felts. These felts make up the high speed belts that squeeze water out of pulp as it is being formed into paper in the papermaking process.

WEB FORMING AND BONDING —NEEDLEPUNCHED



The design of a needle for every application reflects the balance between its fiber tuft carrying capacity, the damage it may do in breaking and abrading the fibers and the function and aesthetics desired in the product. Exciting new loom and needle designs have permitted the production of ribbed and velour surfaces for carpeting, wall coverings and other textured surfaces. For example, a rib pattern is obtained when forked, instead of barbed, needles are used to carry the tufts into channels instead of the customary perforated bed plate. When the needles have a crown profile, and the bed plate is replaced with a bristle brush bed, a random pile velour results.

Needlepunched Nonwovens by End-use (lbs.)



The two largest markets for needlepunched nonwovens are automotive trim and geotextiles. Other major end-uses, in order of importance, are coated/ laminated fabric backings, bedding and home furnishing materials, filters, interlinings, roofing and landscape fabrics. There is an extraordinarily large array of specialized end-uses for custom-designed needlepunched materials. A few examples include craft and decorative felts, desiccant materials, insulation, apparel linings, diaper soaker pads, lubricating pads, marine materials, noise absorbent insulation, office partition fabrics and polishing pads.

Spunlaced

The Spunlaced (hydroentangled) process uses fine, high velocity jets of water to impact a fibrous web and cause the fibers to curl and entangle about each other. The water jets perforate the web and entangle the fibers, producing fabrics that

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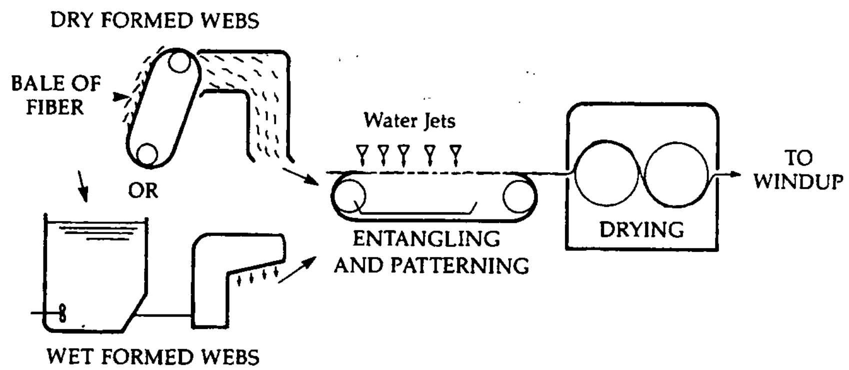
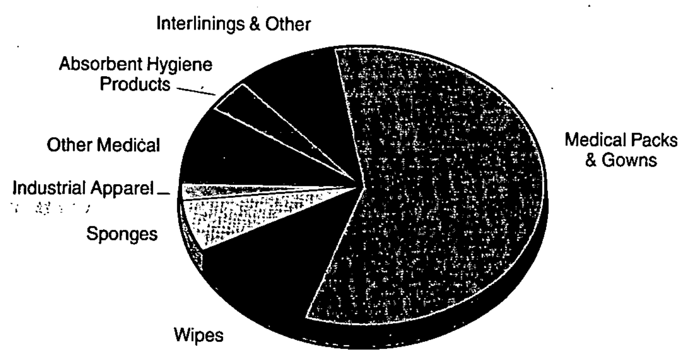
WEB FORMING AND BONDING — SPUNLACED



reflect the pattern of the forming belt which carries the web under the water jets. This produces a fabric with a conventional textile fabric appearance and excellent drapability. Binder is not required. However, a small amount of binder is added to some spunlace fabrics to increase their strength and dimensional stability or to make them liquid repellent.

The process is used predominantly on dry laid webs. More recently it has been successfully used on wet laid webs. A lower energy version of spunlacing, using lower velocity water jets, gives products that require a significant amount of

Spunlaced Nonwovens
(lbs.)



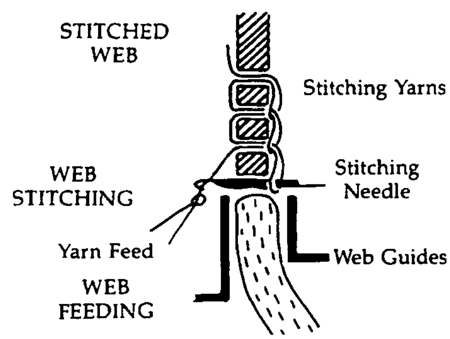
binder to improve their strength since the fibers are less entangled.

Medical packs and gowns are the largest spunlaced application by far. Wipers are the second largest spunlaced end-use followed by medical sponges. A very large number of applications make up the remainder. These include protective industrial apparel, interlinings, mattress pad fabrics, absorbent product components, coated fabric substrates, reinforced plastic components, window treatments and other home furnishings, other medical supplies, automotive components, fire block fabrics, roofing materials, wallcoverings, scrub apparel, filter fabrics, geotextile materials and other advanced composites.

Stitchbonded

A mechanical bonding process called stitchbonded uses a continuous filament or staple yarn to lock a web of unbonded fibers into a fabric with a stitch pattern. This method is used in applications such as shoe components, mattress ticking and coating substrates.

STITCHBONDED



FABRIC FINISHING

Finishing treatments are often applied to webs after bonding. Creping and embossing are treatments that soften and increase the bulk and thereby change the surface texture and the feel of a nonwoven fabric. Printing, generally by a rotary screen, is frequently applied to nonwovens used in home furnishings and other decorative fabrics. Nonwovens can be treated with resins to increase their strength and dimensional stability. Various methods of perforating nonwovens are used to increase the porosity of the materials.

Laminating can be done to form fabrics with complex properties derived from

combining layers of different materials. For example, a high strength fabric can be sandwiched between two soft, weaker fabrics to obtain good strength with textile softness. Examples of other properties that can be obtained in finishing are porosity, breathability, absorbency, repellency, improved hand and other combinations.

Specialty Fabrics

The combination of materials and processes in closely related technologies is often done to create unique products. Hybrid processes combine the property and technology advantages of two or more individual systems to produce fabrics with synergistic properties.

Leathers and Suedes made from synthetic materials can be as breathable and durable as those made from animal hides; and similar in grain and color, and sufficiently soft to be used in clothing.

Leathers are made by impregnating a nonwoven fabric with a solution containing a polyurethane. Treatment with a non-solvent then serves to coagulate the polyurethane and thereby fix it onto the fabric. This structure can be laminated with a thin, microporous polyurethane layer that is given a grain by applying it from a patterned release paper on which it is cast, or by using engraved heated rolls. Gravure rolls are used to further modify the leather's luster and touch.

Suedes are made by brushing and thereby napping the impregnated nonwoven that has been made with extremely fine fibers, or by sanding the polyurethane surface if the fabric has been further coated.

Special fibers have been developed that permit them to be converted into soft, fine fibers and to yield a microporous structure - after the nonwoven has been impregnated. The fibers are made by cospinning two polymers - usually polyester and nylon. If the polymers are mixed before spinning, the fiber has a structure of particulate islands of one polymer in a sea of the other. If the polymers are not mixed, but extruded together, a bicomponent fiber results. A solvent can be then used to dissolve and thereby extract one polymer from the other to give either porous fibers or fibrillar bundles - depending on how the fibers were spun and whether the sea or island component was extracted.

Since solvent extraction is done after the nonwoven has been impregnated with the polyurethane, the fibers are not only made fine and soft, but voids are created within the fibers that provide porosity in addition to that existing in the nonwoven. The nonwoven is usually made by needlepunching or hydroentangling a crosslapped or random laid web.

Laminates are multiple layer structures where the layers are bonded to one